Economic Valuation of Wetland Ecosystem Services: A Case Study of Sarsai Nawar Jheel

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***Abstract*—Wetlands deliver a complex suite of provisioning, regulating, supporting, and cultural services that underpin both ecological health and human prosperity. Nevertheless, these ecosystems—particularly within India's Gangetic floodplain—are routinely undervalued in regional planning and policy frameworks. This study provides a detailed economic valuation of the ecosystem services generated by Sarsai Nawar Jheel, a 161-hectare freshwater marsh in Uttar Pradesh recognized as a Ramsar site in 2019. Using data from the Ministry of Environment, Forest and Climate Change, the Uttar Pradesh State Wetland Authority, and peer-reviewed literature, the research quantifies the economic contributions of three primary ecosystem services: biodiversity conservation, groundwater recharge, and local livelihood support. By applying the Total Economic Value (TEV) framework alongside a benefit transfer methodology adjusted for local biophysical conditions, the study estimates the wetland's aggregate annual economic value to be between INR 4.23 crore and INR 7.90 crore (roughly USD 0.51 million to USD 0.95 million). Biodiversity conservation emerges as the most economically significant service. These findings provide a strong economic justification for increasing conservation investments and highlight the critical need to integrate ecosystem service valuation into formal wetland governance and policy structures.**

***Index Terms*—Ramsar Convention, ecosystem services, economic valuation, benefit transfer, Sarus crane, groundwater recharge, Indo-Gangetic floodplain, Uttar Pradesh.**

I. INTRODUCTION

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Wetlands rank among the Earth's most productive ecosystems, yet they are experiencing unprecedented rates of degradation. Since 1970, roughly 35 percent of global wetlands have disappeared, and those surviving face mounting threats from agricultural intensification, rapid urbanization, hydrological alterations, and climate change Link text. The Gangetic floodplain of northern India offers a clear example of these pressures. This alluvial landscape is dotted with thousands of natural depressions and marshes—remnants of ancient river meanders that act as crucial hubs for biodiversity, water regulation, and rural livelihoods. Sarsai Nawar Jheel, located in the Takha tehsil of Etawah district, Uttar Pradesh, vividly illustrates these ecological and socio-economic dynamics.

Recognized as a Wetland of International Importance by the Ramsar Convention on September 19, 2019, Sarsai Nawar Jheel covers around 161 hectares of permanent shallow marsh within the upper Yamuna River basin Link text. The site is named after the vulnerable Sarus crane (*Antigone antigone*), the tallest flying bird globally, and supports the largest known regional flock of about 400 individuals. Beyond this flagship species, the marsh is home to over 115 bird species, including the critically endangered white-rumped vulture (*Gyps bengalensis*) and the endangered woolly-necked stork (*Ciconia episcopus*). It also serves as a crucial wintering ground for waterfowl navigating the Central Asian Flyway. The local flora, dominated by nut sedge (*Cyperus rotundus*) and various aquatic angiosperms, drives the nutrient cycling and habitat structuring required to sustain this rich biodiversity.

However, the wetland's ecological value is only part of its story. Sarsai Nawar Jheel sits within a heavily agrarian landscape where roughly 1,100 households rely directly on its provisioning services. Locals depend on the marsh for irrigation water, fisheries, livestock fodder, and, increasingly, income from nature-based tourism. Furthermore, the wetland recharges local groundwater aquifers, enabling winter (rabi) crop cultivation across hundreds of hectares. Its hydrological buffering capacity mitigates both monsoon flood peaks and dry-season water

shortages—functions that are becoming increasingly vital amid climate-induced weather variability. On a cultural level, the Hajari Mahadev temple located within the wetland attracts thousands of pilgrims each year, illustrating the deep connection between the region's ecology and its spiritual heritage.

The primary issue this paper tackles is the economic invisibility of these benefits. Despite contributing heavily to regional welfare, the services provided by Sarsai Nawar Jheel are not monetarily quantified in any formal planning documents. For instance, the site's Integrated Management Plan, funded under the National Plan for Conservation of Aquatic Ecosystems (NPCA), allocates INR 368.46 lakhs over four years. This budget is based on administrative precedent rather than a systematic calculation of the economic returns of conservation. Because wetland benefits remain unpriced, conservation efforts are structurally disadvantaged when competing against intensive agriculture or infrastructure projects, which usually present clear, quantified economic justifications.

This study aims to fill that gap by conducting a rigorous economic valuation of three key ecosystem services: biodiversity conservation (including existence value and eco-tourism), groundwater recharge, and local livelihood provisioning (encompassing fisheries, agriculture, and non-timber products). The research addresses three core questions:

1. What is the estimated annual economic value of these specific ecosystem services?
2. How does this value compare to the current public spending on conservation?
3. What are the policy implications of making these values visible to state and district-level planners?

II. LITERATURE REVIEW

Over the past forty years, the economic valuation of wetland ecosystem services has grown from a specialized academic niche into a robust field directly informing environmental policy. This review examines the global conceptual development of the field, the state of wetland valuation in India, and the methodologies commonly employed.

2.1 Global Conceptual Evolution Modern ecosystem valuation was heavily catalyzed by Costanza et al. (1997), who famously estimated the total annual value of global ecosystem services at USD 33 trillion, with inland wetlands accounting for roughly USD 4.9 trillion. While critics debated the methodology—particularly the extrapolation of local willingness-to-pay data to global biomes—the study succeeded in framing ecosystem services as essential economic assets. A 2014 update by Costanza and colleagues assessed land-use changes between 1997 and 2011, estimating global ecosystem service losses at USD 4.3 trillion to USD 20.2 trillion annually, further solidifying the economic argument for conservation.

The Millennium Ecosystem Assessment (2005) subsequently organized ecosystem services into a widely adopted taxonomy: provisioning, regulating, supporting, and cultural services. This classification was later refined by The Economics of Ecosystems and Biodiversity (TEEB) initiative. The TEEB (2013) guidelines advocate a tiered approach to wetland valuation: qualitatively recognizing value, quantitatively demonstrating it, and finally capturing it through targeted policy instruments.

Meta-analyses have further standardized these valuations. Brander et al. (2006) reviewed 80 wetland studies, revealing that regulating services like flood control and water quality improvement carried the highest monetary values. Ghermandi et al. (2010) expanded this to 418 observations, reaffirming the immense value of regulating services while noting that site-specific traits heavily influence outcomes. More recently, Davidson et al. (2019) placed the global monetary value of inland wetlands at approximately USD 27,000 per hectare annually, providing a useful benchmark for benefit transfer studies.

2.2 Wetland Valuation in India In India, the literature on wetland valuation is growing but remains geographically uneven. Research has primarily focused on prominent sites like the East Kolkata Wetlands, Chilika Lake, Loktak Lake, and the Vembanad-Kol system. For example, Kumar et al. (2011) evaluated Chilika Lake's total economic value at about INR 3,550 crore annually, driven largely by fisheries and tourism. The East Kolkata Wetlands were estimated to provide waste treatment services worth INR 4.5 crore daily, a finding that dramatically reshaped local conservation politics. Meanwhile, John and Mathew (2021) utilized benefit transfer to

value groundwater recharge in Kerala's Kole wetlands at USD 1.3 million annually, demonstrating how adaptable this methodology can be in data-scarce environments.

Despite these advancements, the TEEB India Initiative (2016) highlighted severe data deficits regarding wetlands in the Indo-Gangetic plain. At the time of the report, none of the Ramsar sites in western or central Uttar Pradesh had undergone systematic economic valuation. The 2019 Ramsar designation of Sarsai Nawar Jheel makes filling this empirical gap an urgent priority.

2.3 Methodological Approaches The Total Economic Value (TEV) framework remains the standard conceptual tool for this work. It divides value into use values (direct, indirect, and option values) and non-use values (such as existence and bequest values). Provisioning services are typically assessed using market-based methods like net factor income. Regulating services, which lack traditional market prices, are often measured using replacement costs or avoided damage costs. Cultural services generally require survey-based contingent valuation or travel cost methods.

Conducting primary valuation surveys is highly resource-intensive. Consequently, the benefit transfer method—which adapts economic values from existing studies to a new, similar site—is often utilized as a pragmatic alternative. Endorsed by both TEEB and the Ramsar Convention, benefit transfer is reliable as long as researchers carefully calibrate the data to local biophysical conditions. Since no primary economic data exists for Sarsai Nawar Jheel, this study employs benefit transfer, grounding global and regional meta-analytical data with site-specific metrics.

III. METHODOLOGY

3.1 Conceptual Framework This research applies the TEV framework to categorize and assess ecosystem services. Due to data constraints, the study zeroes in on three highly critical and measurable service categories: biodiversity conservation (combining existence and tourism values), groundwater recharge (an indirect use value), and local livelihoods (direct use values including fisheries, agriculture, and non-timber products).

3.2 Valuation Approach The benefit transfer method was executed in five distinct stages:

1. Source Identification: Selecting transferable economic estimates from comparable South Asian wetland studies (e.g., Chilika Lake, Kole wetlands) and global meta-analyses.
2. Biophysical Profiling: Gathering site-specific data for Sarsai Nawar Jheel, including its 161.3-hectare area, 791.6 mm annual rainfall, 240-day inundation period, and biodiversity indices.
3. Socio-Economic Profiling: Mapping the dependency of the approximately 1,100 local households on the wetland's resources.
4. Value Adjustment: Modifying transferred values to account for purchasing power parity, inflation, and unique site characteristics.
5. Sensitivity Analysis: Generating value ranges (low, central, and high estimates) rather than absolute single figures to account for inherent uncertainties.

3.3 Data Sources Secondary data were compiled from the site's Ramsar Information Sheet, the Uttar Pradesh State Wetland Authority's (UPSWA) Integrated Management Plan, Asian Waterbird Census records, and the Central Ground Water Board. District agricultural statistics and eco-tourism data were also utilized to construct a robust local profile.

3.4 Calculation Methods

- Biodiversity Conservation: Existence value was transferred from a Chilika Lake contingent valuation study. After adjusting for regional income disparities, the willingness-to-pay was set at INR 122 per household annually. This was applied to a connected population of 6,100 households. Tourism value was calculated using a travel cost proxy, estimating 5,000 to 8,000 annual visitors spending INR 800 to INR 1,200 each, plus an indirect economic multiplier.
- Groundwater Recharge: A replacement cost approach was used. The annual recharge volume was calculated based on surface area, inundation days, infiltration rates, and aquifer efficiency. This volume was then priced against the local cost of extracting groundwater via diesel borewells (INR 28 to INR 35 per cubic meter).

- Local Livelihoods: Fisheries were valued by estimating the net factor income of an annual 8 to 12 metric tonne harvest, minus operational costs. Agricultural water value was determined by calculating the incremental crop yield of wetland-irrigated farmland compared to rainfed land. Finally, non-timber products like fodder and water chestnuts were priced at local market rates.

IV. ANALYSIS AND FINDINGS

4.1 Biodiversity Conservation Services Applying the adjusted willingness-to-pay of INR 122 to the 6,100 connected households results in a baseline existence value of INR 0.74 crore annually. If extrapolated to the entire Etawah district, this figure would scale drastically, though willingness-to-pay naturally drops as distance from the site increases. Balancing these factors, the study establishes an existence value range of INR 1.50 crore to INR 2.50 crore.

Regarding eco-tourism, direct visitor expenditure is estimated between INR 0.40 crore and INR 0.96 crore. Factoring in a local economic multiplier of 1.4 to 1.6, the total tourism value reaches INR 0.56 crore to INR 1.54 crore.

Combined, the annual value of biodiversity conservation ranges from INR 2.06 crore to INR 4.04 crore, with a central estimate of INR 3.05 crore. Consistent with other high-biodiversity Ramsar sites in India, this represents the largest single economic contribution of the wetland.

4.2 Groundwater Recharge **Services** Given the wetland's 161.3-hectare area and local hydrogeological conditions, the net annual groundwater recharge is calculated at roughly 406,476 cubic meters. This aligns with field observations showing post-monsoon water table rises in the immediate vicinity.

Pricing this volume at the replacement cost of diesel extraction yields a total recharge value of INR 1.14 crore to INR 1.42 crore. When restricting the valuation solely to the water abstracted for agricultural productivity, the adjusted value ranges from INR 0.68 crore to INR 1.14 crore. The study adopts a conservative working range of INR 0.90 crore to INR 1.30 crore per year.

4.3 Local Livelihood Services The local fishery generates a gross annual value between INR 0.96 crore and INR 2.16 crore. Deducting 30 percent for operational expenses leaves a net income of INR 0.67 crore to INR 1.51 crore.

For agriculture, the water supplied by the wetland enhances crop yields across 200 to 350 hectares. This incremental production value is estimated at INR 0.45 crore to INR 0.75 crore annually. Finally, the harvesting of non-timber wetland products contributes a modest but vital INR 0.15 crore to INR 0.30 crore.

In total, local livelihood services provide an annual economic value ranging from INR 1.27 crore to INR 2.56 crore, centering on INR 1.92 crore.

4.4 Aggregate Economic Value

Table 1: Estimated Annual Economic Value of Sarsai Nawar Jheel Ecosystem Services (2024)

Ecosystem Service Category	Low Estimate (INR Crore)	Central Estimate (INR Crore)	High Estimate (INR Crore)
Biodiversity Conservation	2.06	3.05	4.04
Groundwater Recharge	0.90	1.10	1.30
Local Livelihoods	1.27	1.92	2.56
Total	4.23	6.07	7.90

Note: Estimates exclude unmeasured services like carbon sequestration and water purification, making these conservative, lower-bound figures.

The aggregate value of INR 4.23 crore to INR 7.90 crore equates to approximately USD 3,150 to USD 5,900 per hectare, per year. This places Sarsai Nawar Jheel comfortably alongside similar South Asian wetlands when adjusted for local purchasing power.

V. DISCUSSION

5.1 Interpretation of Findings The data yields three critical insights. First, the ecosystem's economic output vastly outweighs the state's financial input.

The current Integrated Management Plan budgets roughly INR 0.92 crore annually for the site. Even the most conservative valuation estimate (INR 4.23 crore) suggests that the wetland generates 4.6 times that amount in public and private benefits, proving that conservation is a highly sound economic investment.

Second, while biodiversity conservation accounts for roughly half of the total economic value, this benefit is diffuse, enjoyed by regional, national, and international stakeholders. Conversely, the opportunity costs of conservation (such as restricted land use) fall heavily on the local agrarian community. This highlights a classic environmental economics dilemma: the mismatch between those who benefit from conservation and those who pay the price for it.

Third, although local livelihood services represent the smallest financial slice of the TEV, they are the most critical for the wetland's survival. The everyday land and water use decisions made by the 1,100 dependent households dictate the ecological future of the site. Therefore, conservation strategies must align ecological goals with local economic incentives.

5.2 Policy Implications

- Budgetary Allocation: The clear 4.6:1 return on investment justifies the rapid disbursement of NPCA funds. Expediting investments in eco-tourism infrastructure and sustainable fisheries will yield immediate economic dividends for the region.
- District Planning Integration: To prevent the wetland from being lost to agricultural encroachment or infrastructure, district planners must integrate these newly visible ecosystem values—especially groundwater recharge—into their formal land-use and water allocation frameworks.
- Payment for Ecosystem Services (PES): The state should formalize PES mechanisms. Reinvesting eco-tourism revenues or introducing nominal water user fees can sustainably fund the wetland's upkeep while financially compensating the local communities who act as its stewards.
- Adaptive Management: Continued, systematic monitoring of hydrology, fishery yields, and tourism metrics will refine future economic valuations and allow for highly responsive, adaptive management of the site.

5.3 Limitations This study acknowledges several limitations. Benefit transfer introduces inherent uncertainties, as extrapolating data from other states cannot perfectly capture local nuances. Furthermore, omitting services like carbon sequestration and flood attenuation means the actual economic value of the wetland is undoubtedly higher than reported. Finally, this valuation provides a static snapshot in time; it does not model future climate scenarios or changing land-use dynamics.

VI. CONCLUSION

This research provides the first systematic economic valuation of Sarsai Nawar Jheel. By applying the Total Economic Value framework, the study conservatively estimates that this Ramsar site generates between INR 4.23 crore and INR 7.90 crore (USD 0.51 million to USD 0.95 million) in annual ecosystem services.

These findings carry urgent implications for regional wetland governance. Because the site’s economic output exceeds current conservation funding by a factor of up to 8.6, there is an irrefutable fiscal mandate to accelerate the implementation of the Integrated Management Plan. Furthermore, addressing the inequity between diffuse global biodiversity benefits and concentrated local opportunity costs is paramount. Sustainable livelihood programs must be operationalized to ensure that local communities directly benefit from protecting the marsh.

Sarsai Nawar Jheel represents a broader trend across India's Ramsar network: internationally celebrated wetlands that remain economically invisible in local planning. Translating their ecological functions into the language of economics is a vital step toward ensuring their permanent protection.

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